GTZ Sustainable Utilization of Natural Resources
for Improved Food Security Energy

Envirofit S-2100

Yue Xiang

Open Fire/Three Stone

Darfur/Berkley

Tikikil

Envirofit B-1100

Water Test Results of Various Types of Household Wood Stoves for Non-Injera Cooking

gtz MoARD

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1 Overview

The supply of household cooking fuels in Ethiopia is predominantly from biomass resources. Fuelwood is the single most important source of cooking energy for the households, particularly in rural areas where alternative sources are either simply unavailable or unaffordable by the majority of the consumers. At present literally all households that burn wood for cooking use Open fire with the exception of very few places where traditional enclosed mud stoves are used for injera baking. Previous government and NGOs efforts in Ethiopia were entirely focused on the development, promotion and dissemination of two types of stoves, namely the Lakech improved charcoal stove and the Mirt improved biomass Injera stove. Very little effort was made in promoting improved wood-burning stoves for non-Injera cooking in the past.

At present, Ministry of Mines and Energy in collaboration with GTZ-Sustainable Utilization of Natural Resources-Energy Project managed to locally adapt and manufacture a low-cost wood stove for household cooking. The stove, known as 'Tikikil' is an adapted version of a 'Rocket' stove originally designed in the USA. As part of a national effort to promote household energy efficiency improvement in a self-sustaining manner, technical training was provided to artisans to ensure local manufacture of the new stove.

On the other hand, there is a growing interest among a few NGOs to import wood stoves with the intention of large scale dissemination in various parts of the country. To this effect sample stoves produced in other parts of the world were imported. It is therefore necessary to technically evaluate all wood stoves available for non-injera cooking from the points of view of not only energy-efficiency (and hence environmentally benign) but also socially acceptability and financial viability to consumers.

Thus, this technical evaluation which includes a series Water Boiling Tests (WBT) and other evaluation/screening criteria were used to evaluate each stove. This report discusses the results of WBT and the outcomes of the screening criteria.

2 Number and type of stoves collected for testing

Table 1 below shows the type of stoves collected for testing from international suppliers and the GTZ SUN Energy Project.

Table 1: Type and number of stoves obtained for testing

No.	Type of Stove	Country of Origin
Stoves imported		
1	Envirofit – Model number S-2100	India
2	Envirofit – Model number B-1100	India
3	Yue – Xiang	China
4	Darfur/ Berkley	USA
	Total Number of Stoves	4
Stoves obtained from GTZ/ Locally Manufactured		
1	"Tikikil"	Ethiopia
2	Open-Fire/ Three-stone	Ethiopia
	Total Number of Stoves	2
	Grand Total	**6**

The Envirofit B-1100 and Yue Xiang stoves are basically the same except that Yue Xiang comes with a skirt (see photos in Annex 4). Therefore, although the total number of stoves obtained for the testing and evaluation was six, in terms of variety, there were only five different types of stoves including Open-fire.

3 Description of stoves tested

Six types of stoves were available for testing. Two of them are different models of Envirofit stoves (S-2100 and B-1100). The third type of stove is known as Yue-Xiang, perhaps manufactured by a company called StoveTec. Yue-Xiang stove has an entirely same dimension as B-1100 stove except the skirt which comes as a separate part of the stove. The fourth one is known as Darfur (also called Berkely stove). The fifth type of stove is a locally manufactured stove known as “Tikikil” meaning “Perfect” in Amharic. A Open-Fire (Three-stone) fire is also tested for comparison. The two Envirofit stoves, Yue-Xiang and “Tikikil” are basically rocket stoves. The description of each stove is as follows:

3.1 Open Fire (Three Stone)

Three Stone open fire stove is widely used for cooking food using biomass fuels such as wood, leaves, dung and agricultural residues. Traditionally, the three pot supports are made with fired clay in a form of hollow cylinderical shapes as indicated in the picture (right). Such type of fired clay pot supports can be obtained from the market at a price of about ETB 5.00. It is also common to use three equal sized stones or standard construction brickes to support pots when cooking. Typical height of pot supports used for cooking in Open-fire ranges between 13 to 15 cm. The height of the pot supports used in this water boiling test was 13.5 cm.

3.2 Local Rocket stove (“Tikikil”)

GTZ SUN Energy (Sustainable Utilization of Natural Resources) has been lately working with local potters and metal artisans for local manufacturing of a household rocket stove which would be affordable for low income households. “Tikikil” is tailer made and optimized to accommodate a 25 cm diameter of pot size which is typical size used in households.

The stove has an inner clay liner for the combustion chamber cladded with sheet metal on the outside. The clay liner is produced by local potters while the metal cladding is done by metal artisans. The stove has non-removable skirt. The wood shelf is made up of 5mm radius round metal bar. At present the retail price of the stove is estimated to be about USD 8.50 (ETB 90).

3.3 Chinese stove (Yue-Xiang)

This stove is manufactured in China. The combustion chamber of the stove is made up of refractory (insulative) clay liner. The stove has a detachable skirt around the pot to enhance the heat transfer and increase the overall thermal efficiency. The pot-rests and the top part of the stove that guides the flue gas through the bottom of the pot are made up of cast iron.

The wood shelf is made up of a round bar of 4mm diameter size. The cost of the stove (FOB Bejing) could range between USD 9.00 to USD11.00. Various taxes on imported stoves include: duty 30%, value added tax 15%, sur tax 10% and withholding tax 3%. The compounded sum of these taxes reaches 67%. The final retail price of the stove could range between USD 17 and USD 20 (ETB 190 to ETB 220).

3.4 Envirofit S-2100 - Indian Chula

This stove is also produced in India. The combustion chamber of the stove is made up of a refractory clay liner. The liner is covered with a metal cladding on the outside. There is air gap between the liner and the metal cladding serving as an insulation.

The wood shelf and the pot-rest are made up of cast iron. With the cast iron and the refractory liner, the stove is expected to last longer.

The cost of the stove (FOB) could range between USD15 to USD18. With the price build up, the retail price of the stove would not be anything less than USD28 (ETB300).

3.5 Envirofit B-1100 -

This stove is another version of the Envirofit stove. It is the same as Yue-Xiang stove mentioned above in terms of dimensions except that this one does not have a skirt. The colour of the stove and the handles are also different from Yue-Xiang but these properties do not affect the performance of the stove.

3.6 Darfur/Berkley stove

This stove is also known as Berkley stove. It is very much similar to the "Vita stove" which was designed by Aprovecho. It is a whole metal stove with cast iron grate. The component of the stove can be packed and shipped un-assembled. This reduces the cost of shipment greatly.

The stove costs (FOB) about USD15. With all taxes added, the consumer retail price of the stove could reach USD 28 (about ETB 300).

4 Evaluation methodology

In order to understand the performance of each of the stoves a series of water boiling tests (WBT) were conducted. The stoves were also evaluated based on their features which contribute to a quick market up take and sustainable dissemination.

The laboratory tests were conducted using the "Shell Foundation Households Energy Project - Water Boiling Test Protocols" which is pretty much the same as the 2003 University of California – Berkeley (UCB) revised protocol. This test protocol is widely accepted as a standard procedure for WBT.

In order to evaluate the stoves for sustainability, a series of criteria were set. The criteria were basically set to evaluate the features of the stoves as to how they affect wider dissemination in the country. See the evaluation criteria in Annex 1.

WBT on progress on selected stoves

Envirofit S-2100

Tikikil

Three Stone/Open Fire

5 Discussion of Test Results

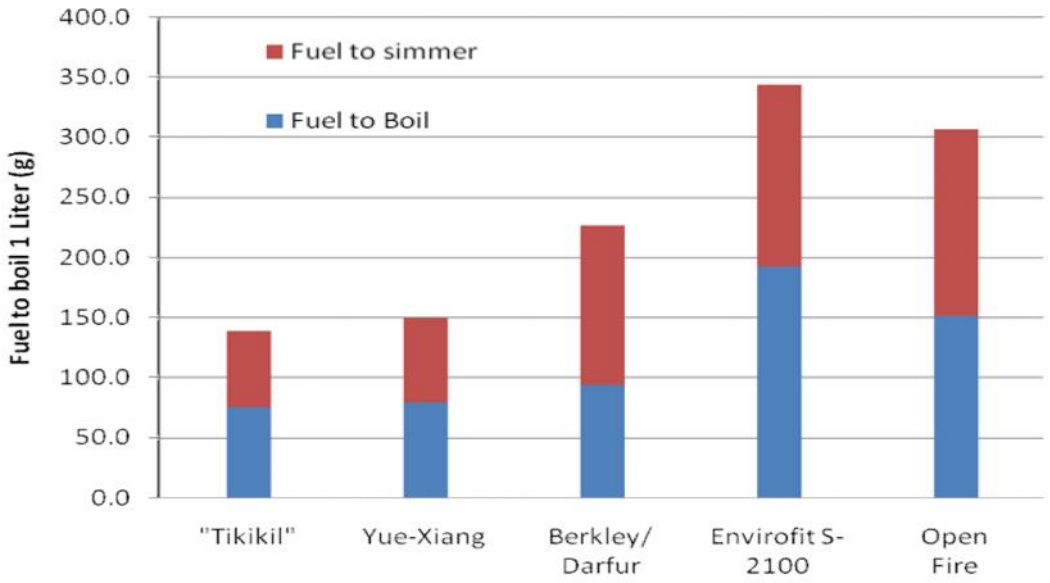
Fuel consumption and time to cook are important parameters that determine the performance of a stove. The comparison between the stoves is made based on their fuel consumption and time needed to bring one liter of water to boiling.

Each stove is tested with a same type of pot with five liters of water. The selected pot size for the test was a 25 centimeters diameter aluminum pot which is the typical pot size available in most households. A single test contains two high power tests (with cold and hot start) and a 45 minutes simmering at a temperature about two degrees lower than boiling temperature.

5.1 Fuel Consumption

Fuel consumption in this regard is the fuel consumed by the stove to bring the water to boiling or simmer. The graph below shows the amount of fuel consumed by each stove to bring one liter of water to boiling and fuel consumption to simmer one liter of water. The fuel consumption for boiling comparison is based on the high power cold start test as it resembles more to the situation in the household (short duration cooking as opposed to long and continuous cooking) than the hot start.

Figure 1: Fuel consumption to boil and simmer one liter of water



From Figure 1 above, “Tikikil” and Yue-Xiang (the one with the skirt) consumed less fuel to boil and simmer one liter of water compared to the other stoves. The fuel consumed to bring one liter of water was 75.2, 79.5, 93.7, 192.7 and 151.5 grams while for simmering it was 64, 70, 134, 152 and 155 grams by “Tikikil”, Yue-Xiang, Darfur, Envirofit S-2100 and Open Fire stoves respectively.

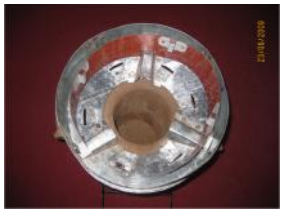
Darfur, Envirofit S-2100 and Open Fire stoves consumed more fuel per liter of water boiled. There are at least three reasons that contributed to the high fuel consumption in these stoves. The first reason was that Envirofit S-2100 stove did not have skirt which was supposed to enhance fuel transfer efficiency. Previous test results by Aprovecho Research Center also confirm that removal of skirt can increase fuel consumption by up to 30%. The WBT conducted in Aprovecho lab in April 2007 indicated that rocket stove with skirt consumed only 80 grams of fuel to bring one liter of water to boiling while without skirt the consumption was raised to about 112 grams. The WBT results presented in Figure 1 above for “Tikikil” and Yue-Xiang is very much similar to that obtained by Aprovecho. However, for Envirofit S-2100 (the one without skirt) was much higher. Both “Tikikil” and Yue-Xiang have skirts which increases the heat transfer to the pot through the pot walls. The skirt, in addition to enhancing the heat transfer, it also shields the pot walls from the ambient air reducing the heat lose from the pot. Moreover, such increased fuel consumption by Envirofit S-2100 and Darfur stoves are primarily due to higher firepower they have as their combustion chambers are slightly bigger than that required for a pots size used in the test. Furthermore, absence of skirt added to high firepower worsens the heat lose.

Both “Tikikil” and Yue-Xiang have skirts. However, the skirt in Yue-Xiang is detachable. This nature of the stove might cause the users to abandon the skirt easily. If the stove is used without the skirt, the fuel consumption will be significantly increased. This is also the main reason for GTZ SUN Energy project to work on having a permanently fixed or non-removable skirt on its latest version of "Tikikil"

However the project has also worked on a possibility of integrating detachable skirt with a lesser pot size to accommodate multi pot sizes as shown in fig below. Having this additional skirt incur from 3-5 ETB more on the overall cost of the stove.

a- Additional skirt with insertion edge (grooves)

b- Additional skirt fitted to the stove to accommodate lesser pot size (view from top).



5.2 Thermal Efficiency

Fuel consumption per volume of food cooked or water boiled (commonly known as fuel consumption index – FCI) is an easy concept to understand than thermal efficiency. However, it is not the best method of estimating the performance of the stove as it cannot clearly consider the fuel consumed per water boiled and evaporated. Thermal efficiency considers both the amount of water heated and evaporated relative to the fuel consumed. Comparison of stoves by their thermal efficiencies is a better method to compare fuel saving potential of stoves.

Table 1:- Thermal efficiency of the stoves

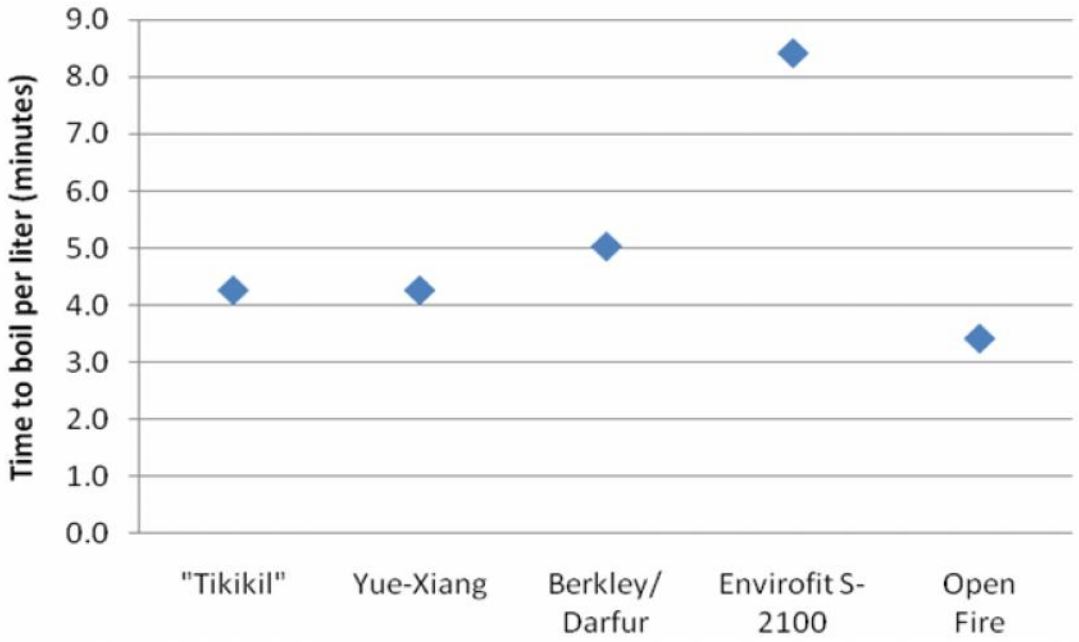
Type of Test	Type of Stoves				
	"Tikikil"	Yue-Xiang	Berkley/ Darfur	Envirofit S-2100	Open Fire
High Power	0.26	0.26	0.24	0.14	0.12
Simmering	0.41	0.30	0.20	0.16	0.17

In the high power test “Tikikil” and Yue-Xiang achieved 26% followed by Darfur stove, 24%. In the simmering test “Tikikil” performed better. For reasons discussed above, Envirofit S-2100 did not perform well in both high power and simmering tests. Previous test results with slightly different WBT methodology showed that the thermal efficiency of Open Fire is in the range between 8 to 10%. In this test a slightly higher efficiency of 12% was achieved in Open Fire. This could be due to the use of a fairly dry wood of 10% moisture content on wet weight basis and a carefully tended and shielded fire.

5.3 Time to Boil

Boiling time resembles cooking time. Speed of cooking is one of the important parameters of stoves that households appreciate most.

Figure 2: Time required to boil one liter of water

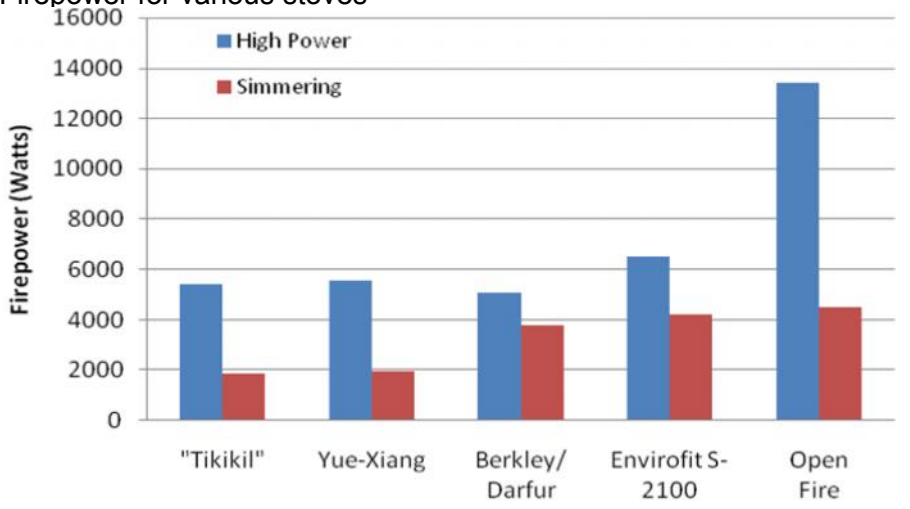


Open Fire stove is the fastest stove to boil water. It took only 3.3 minutes to boil a liter of water. “Tikikil” and Yue-Xiang stoves took 4.3 minutes each to bring one liter of water to boiling. Envirofit S-2100 took longer (8.4min.) as much of the heat generated was lost to the surrounding instead of heating the water in the pot. This has also been confirmed by the test conducted by Aprovecho in that the rocket stove tested without skirt took about 7.2 minutes. Darfur stove took 5.0 minutes to boil a liter of water.

5.4 Firepower

A higher firepower was observed in Envirofit S-2100 stove. This is likely due to the fact that this stove has a relatively larger combustion chamber. If high firepower is combined with good heat transfer efficiency then the time to boil will be reduced. However, the observed high power in Envirofit S-2100 stove was not assisted by good heat transfer efficiency and hence resulted in increased heat lose. A stove with very good heat transfer efficiency can simmer food with minimum firepower. In the case of Envirofit S-2100 and Darfur stoves, the firepower required to keep the water simmering at a temperature about 2 degree centigrade less than boiling temperature is relatively higher than that needed by “Tikikil” and Yue-Xiang Stoves.

Figure 3: Firepower for various stoves



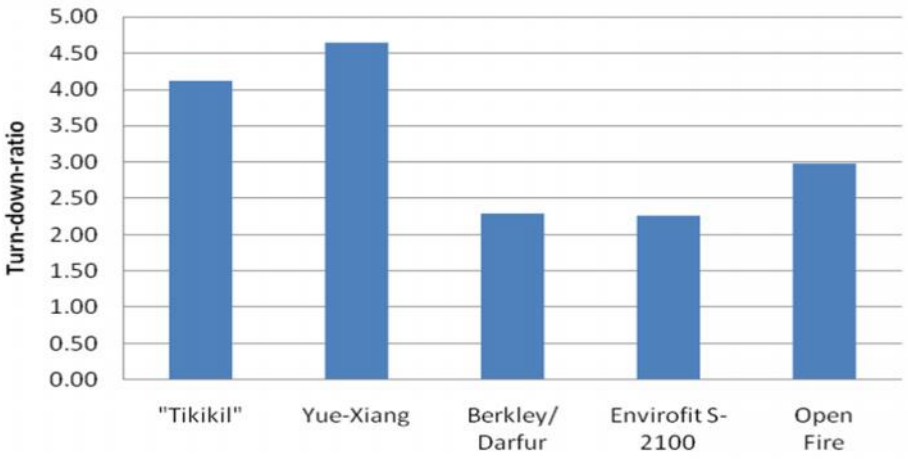
More wood had to be burned in Envirofit S-2100 stove to bring the water to boiling in an acceptable time. This raised the high power cold start firepower to about 6500 Watts. The firepower required for simmering the water just below the boiling point was also higher (4200 Watts) for this stove. Open Fire has the highest firepower. Since the combustion chamber is open and no structure to guide the heat generated to the pot for increased heat transfer, more fire had to be burned to let the required amount of heat transfered into the pot. The high power cold-start firepower for the other stoves was in the range between 5000 to 5500 Watts.

“Tikikil” and Yue-Xinag had a lower firepower of 1900 Watts during simmering. Darfur and Envirofit S-2100 stoves had higher firepower even during simmering. This means more wood has to be burned to maintain even the minimum heat needed for simmering.

5.5 Turn down ratio

Turn down ratio is the ratio of the high power firepower to the simmering firepower. A higher turn-down ratio tells the flexibility of the stove in regulating the intensity of the fire. It is also a good indicator of the performance of the stove.

Figure 4: Turn down ratio



Yue-Xiang has the highest turn-down-ratio of 4.6 followed by 4.1 for “Tikikil”. Darfur and Envirofit S-2100 have similar turn down ratio of 2.3.

5.6 Fuel Saving Compared to Open Fire

Improved stoves are mostly valued by the amount of fuels and Indoor Air Pollutions (IAP) they reduced compared to existing stoves. No IAP measurement was taken. The fuel saving comparison of the stoves over Open Fire is show in Table 2 below. It is calculated using the thermal efficiencies of the stoves.

Table 2: Percentage of Fuel Saving of the stoves over Open Fire

Type of Test	Type of Stoves			
	"Tikikil"	Yue-Xiang	Berkley/ Darfur	Envirofit S-2100
High Power	55.27	55.50	45.29	7.53
Simmering	71.44	38.71	9.56	-1.93
Average	63.35	47.10	27.43	2.80

Comparisons based on the high power test shows that “Tikikil” and Yue-Xiang have the highest fuel saving of 55% over Open Fire followed by Darfur stove (45%). In the simmering phase, “Tikikil” showed a higher saving of about 71% followed by Yue-Xiang (39%) and Darfur (10%). The fuel saving with Envirofit S-2100 in the simmering test is literally nil. Evaluation of stoves based on average fuels saving (i.e. high power and simmering) over Open-fire shows that “Tikikil” saved 63% followed by Yue-Xiang (47%), Darfur (27%) and Envirofit S-2100 (3%).
Actual fuel saving of stoves should be obtained from field tests in real households’ conditions. A longitudinal kitchen Performance Test (KPT) with existing (i.e. Open-Fire) and the new stove need to be conducted. The fuel saving obtained from WBT is just indicative.

6 Evaluation of stoves

In the process of selection of appropriate stove for further dissemination, several issues need to be critically observed. Performance of a stove is one important parameter but other issues are also equally important for the successful dissemination. A set of evaluation criteria was formulated to address such issues. These criteria try to address issues related to safety, functionality, consumer appeal, performance and sustainability. Each of these points was given a weight depending on their importance. Based on the evaluation criteria "Tikikil" stove scored the highest point of 3.6 out of 4.0, followed by Yue-Xiang (3.5), Darfur (3.3) and Envirofit S-2100 (3.0). For details see Annex 1 and Annex 3.

7 Summary and way forward

As far as thermal efficiency is concerned, difference between performance of the two stoves models (Tikikil and Yue-Xiang) is marginal. However, this is true only when the Yue-Xiang stove is used with the accompanying removable skirt on. Using the Yue-Xiang stoves without the skirt compromises fuel-saving capacities of the stove significantly; and there is no guarantee that consumers will use the stove with the skirt on. In fact, previous observations by GTZ SUN Energy staff indicated that consumers tend to be negligent when it comes to proper and regular use of skirt on stove if it is not made as fixed part of the stove.

Based on the sustainability criteria of stove dissemination, affordability and possibility of local manufacturing are critical. In Ethiopia, households that use wood for non-Injera cooking, especially when other better fuels such as kerosene, electricity, LPG and charcoal are available, are in general from lower income categories. Several studies in the past have also confirmed this. Therefore, a wood stove for non-injera cooking should be affordable to lower income households. Moreover, local manufacturing of stove should also be seen from the point of view of value addition and implication on local job creation. In this regard, "Tikikil" should be the choice for wider dissemination in the country.

Annexes

Annex 1: Screening criteria used in selecting stove designs

This is a suggested evaluation criteria which help evaluate stoves with a potential for a quick market uptake and an acceptable safety standard for household cooking. It will also be used together with Water Boiling Test (WBT) result to rank stoves.

Description of stoves

Table 1:- Types of stoves that need to be tested.

No.	Stove Name	Origin/ made	Remark
1	"Tikikil"	Ethiopia – GTZ	Locally manufactured household stove
2	Envirofit S-2100 (Indian Chula)	India/China	Imported from India
3	Barkley/ Darfur	USA	Imported
4	Yue-Xiang	China	Imported from China

Evaluation Criteria

The preliminary criteria are based on only physical inspections. The criteria are divided into three groups as safety risk, functionality, design and affordability. Each criterion under the group will be evaluated as High, Medium, Low, and Minimum having associated values of 4, 3, 2 and 1 respectively. Failing to fulfil certain criteria (those indicated by asterisk below) will result an outright rejection of the stove. Each one of these criteria by itself should be a sufficient condition to drop a stove.

Table 2:- Screening Criteria

No.	Criteria Group	Criteria	Rank Range (1 to 4)	Remark
1	**Stove Safety risk**	*Stability	Yes or No	
2		Handling		
3		Surface Temperature		
4		Containment of Combustion		
5		Sharp Edges/Points		
6	**Stove Functionality**	Ease of lighting		
7		Convenience		
8		Rang of pots accommodated		
9		Multi fuel (biomass)		
10		Containment of ash and embers		
11		*Power generated (>=1kW)	Yes or No	
12	**Consumer appeal**	Durability		
13		Aesthetics		
14	**Performance**	Thermal efficiency		
15	**Sustainability**	Room for local manufacture		
16		Cultural acceptance		
17		Commercialization prospect		
18		Long term financial sustainability		

Ranking:- High/V.Good = 4; Medium/Good = 3; Low = 2; Minimal/Poor =1;

Most of these criteria are taken from Safety Protocols developed by Nathan G. Johnson from Iowa State University. They have been used to test many stoves, and are generally accepted by most experts working with improved cook stoves as a fair assessment.

Illustration of Criteria Used:

- Stability – the tendency of the stove to fall down and tip over pots due to actions performed during operation; while stirring the food, accidental pushes, etc,
- Handling – portability, size,
- Surface Temperature –any surface of the stove body touchable during cooking should not be hotter than that can be touched (including the handles),
- Containment of Combustion - Flame/ Heat surrounding cook-pot, flame/ heat which can harm the cook while cooking (i.e. stirring),
- Sharp Edges/Points – that can cause cuts while handling the stove,
- Ease of lighting – How difficult is lighting or how long does it take to be ready,
- Convenience – refers mainly to ease of use and cooking speed,
- Range of pots accommodated – the stove should accommodated pot sizes mostly used in the households.
- Multi fuel – different types of biomass fuels that can burn on the stove (i.e. wood, Branches, leaves and twigs, agree residues, etc),
- Containment of ash – a good stove should contain the ash inside the stove so that the cook can dispose it off when necessary,
- Power generated – Minimum firepower (Power input) must at least be 1kW although some of Ethiopian dishes like '*wot*' cooking require a fire output of about 600W, other kinds of cooking which require boiling need greater power. It is therefore recommended that the stove should have the minimum power output of 1kW. It is always possible for the households to reduce the power by managing the fuel but not the vice versa.
- Durability – durability of the stove and various parts of the stove – the workmanship, the material used, etc,
- Aesthetics – the attractiveness of the stove,
- Performance – refers to the thermal efficiency of the stove (or relative fuel saving over the traditional stove it replaces). This will be determined by Water Boiling Tests that will be conducted on each one of the candidate stoves,
- Affordability – price of stoves should be within the range that target households can afford.
- Room for local manufacture – refers to possibility of manufacturing the stove in the country. This should be seen from the point of view of value addition and implication on local job creation.
- Cultural acceptance – it may not be possible to evaluate the stove on this aspect before placing it in the households and get the feed-back,
- Commercialization prospects – it may be related to the physical design of a stove which includes sizes, weight, etc that make it an off-the-shelf item. Experience with the local biomass 'Injera' baking stove can be reviewed.
- Long term financial sustainability – relates to affordability and availability of financing mechanisms.

Annex 2: Details of Water Boiling Test Results

Type of Test	Units	"Tikikil"	Yue-Xiang	Berkley/ Darfur	Envirofit S-2100	Open Fire
1. HIGH POWER TEST (COLD START)						
Time to boil	min	21.3	21.3	25.2	42.1	17
Burning rate	g/min	17.2	17.7	16.2	20.7	43
Thermal efficiency	--	0.26	0.26	0.24	0.14	0.12
Specific fuel consumption	g/liter	75.0	77.2	93.8	187.4	143
Temp-corrected specific consumption	g/liter	75.2	79.5	93.7	192.7	151
Firepower	watts	5410	5555	5097	6495	13,431
2. HIGH POWER TEST (HOT START)						
Time to boil Pot	min	15.3	18.0	22.7	32.2	18
Burning rate	g/min	24.0	25.0	21.5	30.9	52
Thermal efficiency	--	0.25	0.26	0.20	0.12	0.09
Specific fuel consumption	g/liter	74.8	93.3	100.2	196.6	177
Temp-corrected specific consumption	g/liter	76.9	99.4	102.7	212.1	190
Firepower	watts	7528	7845	6758	9716	16,191
3. LOW POWER (SIMMER)						
Burning rate	g/min	6.0	6.3	12.1	13.5	14
Thermal efficiency	--	0.41	0.30	0.20	0.16	0.17
Specific fuel consumption	g/liter	64.1	70.0	133.5	151.8	155
Firepower	watts	1888	1979	3807	4236	4,502
Turn down ratio	--	4.11	4.64	2.29	2.26	2.98

Annex 3: Evaluation of stoves
(See annex 1 above for explanation)

No.	Criteria Group	Criteria	Weigh t (%)	Envirofit S-2100 (Indian Chula)	(Yuen Xieng)	Darfur Stove	"Tikikil" Local Rocket Stove	Full
1	Stove Safety risk	*Stability (Yes/No)		Yes	Yes	Yes	Yes	Yes
2		Handling (3%)	2%	4	4	4	4	4
3		Surface Temperature (2%)	2%	4	4	2	3	4
4		Containment of Combustion (3%)	5%	2	4	4	4	4
5		Sharp Edges/Points (2%)	2%	4	4	4	3	4
6	Stove Functionality	Ease of lighting (5%)	5%	4	4	4	4	4
7		Convenience (15%)	15%	4	4	4	4	4
8		Rang of pots accommodated (5%)	5%	4	4	4	3	4
9		Multi fuel (biomass) (2%)	2%	3	3	3	3	4
10		Containment of ash and embers (3%)	2%	4	4	2	4	4
11		*Power generated (>=1kW) (Yes/No)		Yes	Yes	Yes	Yes	Yes
12	Consumer appeal	Durability (8%)	8%	4	4	4	2	4
13		Aesthetics (8%)	10%	4	4	4	3	4
14	Performance	Thermal efficiency (20%)	20%	2	4	3	4	4
15	Sustainability	Room for local manufacture (10%)	10%	1	1	2	4	4
16		Cultural acceptance (2%)	2%	3	3	3	3	4
17		Commercialization prospect (5%)	5%	4	4	4	4	4
18		Long term financial sustainability (5%)	5%	1	1	1	3	4
Total			100%	3.01	3.51	3.33	3.56	4

Ranking:- High/V.Good = 4; Medium/Good = 3; Low = 2; Minimal/Poor =1;

Annex 4: Pictures of stoves collected for testing

Envirofit S-2100

Yue Xiang

Open Fire/Three Stone

Darfur/Berkley

Tikikil

Envirofit B-1100